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ABSTRACT

A statistical comparison was made between two automated devices which were used to count data points (words, sentences, and syllables) needed in the Flesch Reading Ease Score to determine the reading grade level of written material. Determination of grade level of all Rate Training Manuals and Non-Resident Career Courses had been requested by the Chief of Naval Education and Training Support. The devices compared were the Automated Flesch Count (AFC) developed by Kincaid and McDaniel and The Navy Automated Counter (NAC), a pencil-like stylus with a pressure-sensitive switch, developed by the Navy. Comparisons were made between the speed and reliability of the automated devices, and between the speed and reliability of each device and the manual method of counting data points. Similar reliabilities were found for both of the devices and for the manual method. Counts made using the devices were done almost twice as fast as manual counts. The NAC was 20% faster than the AFC, but this difference may be attributable to a practice advantage. The use of an automated device such as the NAC or AFC is recommended as being the most cost-effective technique available for any readability study which involves detailed counting. (MKM)

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CNETS REPORT 5-75

AN EFFECTIVENESS EVALUATION BETWEEN MANUAL AND AUTOMATED READABILITY COUNTING TECHNIQUES

Prepared for
THE CHIEF OF NAVAL EDUCATION AND TRAINING SUPPORT
By
GARY R. BUNDE

AUGUST 1975

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1. CNETS Study Report 5-75, "An Effectiveness Evaluation between Manual and Automated Readability Counting Techniques" is promulgated for information.

2. The conclusions and recommendations contained in the report are those of the writer and are not necessarily those of the Chief of Naval Education and Training Support.

3. This publication has been reviewed under the provisions of SECNAVINST 5600.16 and is approved.

WAYNE P. HUGHES, JR.

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1.0 SUMMARY. A statistical comparison was made between two automated devices which were used to count words, sentences and syllables (data points which are needed in the Flesch Reading Ease Score to determine the reading grade level of written material). The devices are the Automated Flesch Count (AFC) developed by Kincaid and McDaniel and the Navy Automated Counter (NAC) developed by the Navy to conduct a readability study of rate training and correspondence manuals. Comparisons were made between the speed and reliability of the automated devices, and between the speed and reliability of each device and the manual method of counting data points.

Similar reliabilities were found for both of the devices and for the manual method. Counts made using the devices, however, were done almost twice as fast as counts done manually. The NAC was 20% faster than the AFC, but this difference may be largely attributed to a practice advantage which the subjects using the NAC had over the subjects using the AFC. Nevertheless, for any readability study which involves detailed counting of words, sentences, syllables, or similar data points, use of an automated device such as the NAC or AFC is highly recommended as being the most cost-effective technique available.

2.0 ACKNOWLEDGEMENTS. This evaluation could not have been

undertaken without those people who patiently served as subjects. It was particularly difficult for them to count data points manually after spending two months using the speedier and more convenient automated counting device. Sincere appreciation is expressed to those who ably and conscientiously assisted in both the design and conduct of this study. Particular thanks are extended to: Mr. W. Birdsall, Naval Education and Training Program Development Center, who willingly explained the task to the subjects, timed the counts, and recorded data; Mr. R. Doucette, also at the Program Development Center, who performed the statistical analysis; Mr. W. McDaniel, who provided comparison data; and LCDR R. Biersner, MSC, USN, who assisted in the study design, edited the manuscript, and provided patient and professional support.

3.0 PURPOSE. The purpose of this report is to present the results of a comparison between two automated devices which were used to count words, sentences, and syllables. These data points (words, sentences, and syllables) are needed in some reading formulas for determining the reading grade level of written material.

4.0 BACKGROUND. The Chief of Naval Education and Training Support (CNETS) recently initiated a study to determine the

reading grade level of all Rate Training Manuals (RTMs) and Non-Resident Career Courses (NRCCs)(see Reference 1). To conduct this study, a Readability Working Group was formed. After analyzing several measures of readability, the Readability Working Group chose the Flesch Reading Ease Score (see Reference 2) as the most valid and feasible measure to use. The Flesch Reading Ease Score required that a sample of 25 or more passages be selected from each NRCC and RTM. The passages were from 100 to 150 words in length, and a count had to be made of the number of words, sentences and syllables in each passage. Over 14,000 sample passages from 188 NRCCs and 185 RTMs were counted during the course of the study. At the initial stage of this study the Readability Working Group decided that using a manual method (i.e., a pointer to track position and summing the count by memory) would be highly unreliable and extremely tedious for this number of passages. A search of the literature was conducted to find a better method, and two possibilities were found. The first was the Automated Readability Index (ARI) developed by Smith and Senter (see Reference 5). The ARI consisted of a modified electric typewriter connected to a tabulator which recorded the number of strokes (letters), words and sentences in a sample passage as the passage was typed. Average word and average sentence length could then be calculated, and these data used in a regression equation

to obtain reading grade level. The second method was the Automated Flesch Count (AFC) (see Reference 3). The AFC used a simple apparatus -- an electronic counter and metronome -- to count data points (syllables, words, and sentences). These data points were counted in synchrony with a metronome which actuated the counter. A manually controlled switch started and stopped the counter at the beginning and end of each passage. A description of the AFC may be found in Appendix A.

Some difficulties were associated with both of the above methods. Although the ARI was highly reliable and valid, it was not as cost-effective as the AFC. It would have been necessary to purchase and modify several electric typewriters, and only specially qualified typists could have operated the machines. The major disadvantage of the AFC was that the personnel who would be doing the counting would be in the same room, and the noise of eight to twelve metronomes operating simultaneously may have been too distracting to obtain a reliable count.

A third alternative, devised by the CNETS Readability Working Group, was based on the AFC principle. The metronome was replaced by a stylus with a pressure-sensitive switch. The stylus was designed like a pencil so that it could be pointed at each syllable, word, and sentence to be counted. Pressing the stylus against the page activated an

electro-mechanical counter which totalled each of the data points. The specifications for this device, which has been named the Navy Automated Counter (NAC), can be found in Appendix B. The NAC was easy to operate, simple to construct, quiet, and inexpensive.

Previous results obtained by McDaniel (see Reference 4) have compared the AFC with manual methods of counting words, sentences, and syllables. McDaniel used eight college students to count data points both manually and with the AFC. The sample passages to be counted were twenty paragraphs of the "Minnesota Reading Examination for College Students", Forms A and B. The number of seconds taken to count the three sets of data points in each passage were recorded, and reliabilities (determined through interanalyst coefficients) were computed. Reliabilities for the three sets of data points were high (over .89) for both the manual and AFC methods. McDaniel found that the AFC was significantly faster than the manual method in counting syllables. The AFC and the manual method were about the same, however, in the number of seconds taken to count words and sentences.

A determination was therefore made of the speed and reliability of the NAC. The NAC was compared to both the manual and AFC methods. The results of this comparison are presented in the following paragraphs.

5.0 METHOD. The following personnel, procedures, and data were used or collected during this comparison study.

5.1 Subject Personnel. The subject personnel who did the counting were the same personnel who collected the data points for the CNETS readability study mentioned previously in paragraph 4.0. They included 15 females and one male who were selected from 33 applicants by means of a structured screening process, including a reading skill test. The mean age of the subject personnel was 32.3 years (ranging from 18 to 56 years). Formal education ranged from 12 to 18 years (averaging 14.5 years). The education level of this group was comparable to the subjects used by McDaniel.

5.2 Procedures. Because these subject personnel were already committed to the CNETS readability study, it was decided that a study similar to that conducted by McDaniel was not feasible. The analysis was therefore shortened by having these pesonnel count only ten passages (Form A) of the "Minnesota Reading Examination for College Students" instead of the 20 passages used by McDaniel. The subject personnel were asked to do these counts during breaks in the readability study. These personnel had already practiced the NAC method for about two months during the readability study. In addition, they had previously counted the RTM and NRCC materials for about three days using the manual method. They were, therefore, well practiced in both methods.

The sixteen subject personnel were randomly divided into two groups (1-8 and 9-16). In order to insure that the two groups had comparable counting skills for the manual and NAC methods, both groups counted passage I manually and passage II using the NAC. These counting methods were then alternated for each group for passages III through X. Group 1-8 counted odd-numbered passages manually and even-numbered passages automatically. Groups 9-16 counted odd-numbered passages automatically and even-numbered passages manually. The syllables in each passage were counted first, followed by a count of words and then a count of sentences. Table 1 presents a graphic summary of the testing procedure used for each group.

Since only half of the sample passages used by McDaniel were used in this study, a new analysis of the McDaniel data had to be made. The original data were subsequently obtained for seven of the eight McDaniel subject personnel. These data included the number of seconds taken by the McDaniel group to count the syllables, words and sentences in the ten sample passages using the manual and AFC methods. A direct comparison of data could therefore be made between the McDaniel group and the present group.

5.3 Statistical Analyses. The following comparisons were tested for significant differences using conventional t-tests (p .05;two-tailed):

a. Mean reliability of counting words, sentences and syllables between Navy groups 1-8 and 9-16 for passages I (manual method) and II (NAC). Reliability was determined using the standard error of the mean.

b. Mean reliability between (1) the manual method and each of the automated methods (NAC and AFC) and (2) between the NAC and AFC. Again, reliability was determined using the standard error of the mean.

c. Mean speed between the manual and automated methods for the McDaniel group.

d. Mean speed between the manual and automated methods for the Navy group (groups 1-8 and 9-16 combined).

e. Mean speed of the manual method between the Navy group and the McDaniel group.

f. Mean speed of the automated methods for the Navy group and the McDaniel group.

6.0 RESULTS. The following paragraphs present the results of these analyses.

6.1 Comparison of Navy Groups 1-8 and 9-16 for Reliability. Reliabilities between groups 1-8 and 9-16 on passage I (which was done by both groups manually) and passage II (which was done by both groups using the NAC) are presented on Table 2. The reliabilities of the two groups in counting the data points manually and with the NAC were

found to be similar. These findings indicate that the two groups were counting the data points in a similar fashion for both techniques (manual and NAC). Because of these similarities, the two groups will be referred to as a single Navy group.

6.2 Comparison of Reliability Among Methods. This comparison was made using passages III through X as counted by the Navy and McDaniel groups. The reliabilities of the automated methods (AFC and NAC) in counting data points were found to be similar to each other, as well as similar to the manual method. This finding replicates the results found earlier by McDaniel (see reference 4).

6.3 Comparison of Speed Between Manual and Automated Methods. Table 3 presents the number of seconds taken to perform the counts using the manual and automated methods. For the Navy group, syllables, words, and total count (the total number of seconds taken to count syllables, words, and sentences combined) were performed significantly faster by the NAC than by the manual method. Speed for counting sentences was the same using both methods. The McDaniel group performed syllables and total counts faster with the AFC than the manual method, but counting words and sentences was similar for both the AFC and manual methods.

6.4 Comparison Between the Navy Group and the McDaniel Group for Speed of Manual Methods. A determination was made

as to whether the two groups were equally fast in manually counting words, sentences, and syllables. Statistics for this comparison are shown on Table 4 for passages I, and III through X combined. The Navy group was found to manually count syllables significantly faster than the McDaniel group (an average of nearly 1 minute and 20 seconds faster for each passage). This difference was so large that total count was significantly faster as well. Speed for counting words and sentences was, however, similar for the two groups.

6.5 Comparison Between the Navy Group and the McDaniel Group for Speed of Automated Methods. A determination was also made of whether the AFC and the NAC methods differed in speed. Statistics for the two groups on passages II through X combined are shown on Table 5. The data in Table 5 show that the NAC was significantly faster than the AFC for counting syllables, words, and total count. The AFC was significantly faster than the NAC for counting sentences. It must be remembered, however, that the Navy group also counted syllables and total count faster manually than the McDaniel group, and this effect may have made for faster automated speeds.

7.0 DISCUSSION. The results show that the McDaniel and the Navy groups were equally reliable in counting the data

points manually. It was also found that the counts from the two devices were equally and highly reliable, and comparable in reliability to the manual method. The two groups were also compared on the speed with which data points were manually counted. If the groups were equally fast in counting manually, then differences in speed using the automated methods would be the result of the devices and not of the subject personnel. It was found, however, that the Navy group was similar to the McDaniel group in manually counting word and sentences, but the Navy group manually counted syllables significantly faster than the McDaniel group. This difference in syllable count also made for a faster total count. The faster syllable count may have resulted from the more extensive practice which the Navy group had at counting syllables prior to being tested on these sample passages.

Subsequent comparisons of speed using the automated methods showed that the NAC counted words and syllables faster than the AFC, while the AFC was faster than the NAC in counting sentences. Inasmuch as the two groups were comparable in manually counting words and sentences, it is assumed that differences in automated word and sentence counts are related to the devices and not to skill or practice differences between the groups. A definite conclusion about differences in syllable count between the two

devices cannot be made from these data because of possible practice effects noted above for the manual method.

It should also be mentioned that the NAC appeared to be more adaptable to the unique counting styles of the subject personnel. Some subjects pointed at each data point and others tapped the stylus on the table. In addition, the subject personnel could easily stop counting midway through a passage, and resume counting later without losing the total count to that point.

Comparisons between the manual and automated methods showed that the AFC was significantly faster than the manual method at counting syllables. This reduction in syllable count reduced the total time to analyze the sample passages by 45%. The NAC was equally effective in reducing the speed of syllable counts, and in addition the NAC was faster than the manual method at counting words. The NAC reduced total time by 46% over the manual method, and also reduced total time by 20% over the AFC, largely because of the syllable count differences which may have been related to a practice effect.

The above time savings can be readily converted into cost savings. The subject personnel were being paid approximately $3.00 per hour to count sample passages from RTMs and NRCCs. If these personnel had counted the 14,000 passages manually, it would have taken a total of 1,727

hours, and cost a total of $5,181. To do the same number of passages using the NAC, it would take 917 hours and cost $2,751. The savings resulting from use of the NAC would be $2,430. If the AFC had been used, it would have taken the subject personnel 1,082 hours, and cost $3,246. Total savings accrued from using the NAC compared to the AFC would be $495.00. As mentioned above, this savings may not be valid because of practice differences between the two groups.

Many measures of reading grade levels depend on word sentence, and syllable counts. Of the approximately 40 measures currently in use, at least half, including many of the most popular measures such as FOG, INDEX, Flesch Reading Ease Score, Forcast, Ride, and the Automated Reading Index, depend on these or similar data points. These measures are often used in situations in which a large number of samples must be analyzed. As long as these measures remain popular, automated methods (such as the NAC) which improve the speed and reliability of data point collection, will continue to be extremely useful and cost effective.

As a final note, although the NAC had been used primarily to count words, sentences, and syllables, it does have application in any situation in which simple counting is required. The device has been used to score responses on data sheets for research purposes, and is currently being

used by the Naval Education and Training Program Development Center to score some advancement examinations.

TABLE 1

Testing Procedure Used by Navy Groups 1-8 and 9-16
in Counting Manually or with the NAC.

Sample Passages

	I	II	III	IV	V	VI	VII	VIII	IX	X
Group 1-8	M	A	M	A	M	A	M	A	M	A
Group 9-16	M	A	A	M	A	M	A	M	A	M

M = Manual

A = Navy Automated Counter

TABLE 2

Standard Errors of the Means and Ninety-Five Percent Confidence Intervals for Groups 1-8 and 9-16, on syllable, word, and sentence count (Manual and Automated Methods).

MANUAL (PASSAGE I)

	Means	Ninety-five Percent Confidence Interval	
Syllables			
Group 1-8	237.87	237.04	238.70
Group 9-16	236.00	230.43	241.57
Words			
Group 1-8	173.37	172.95	173.79
Group 9-16	173.62	170.41	176.83
Sentences			
Group 1-8	9.00	8.91	9.09
Group 9-16	9.00	8.91	9.09

NAC (PASSAGE II)

	Means	Ninety-five Percent Confidence Interval	
Syllables			
Group 1-8	210.62	210.01	211.23
Group 9-16	210.62	209.63	211.61
Words			
Group 1-8	129.50	129.04	129.96
Group 9-16	129.00	128.54	129.46
Sentences			
Group 1-8	4.25	3.82	4.63
Group 9-16	4.37	3.95	4.79

TABLE 3

Comparison of Speed (in seconds) between the Manual and Automated Methods for the Navy and McDaniel Groups (Passages III-X).

NAVY GROUP

	Manual	NAC	t-tests
Syllables			
Mean	272.42	113.38	11.96**
S.D.	100.45	32.40	df=126
Words			
Mean	120.30	76.48	4.72**
S.D.	71.58	17.59	df=126
Sentences			
Mean	51.42	45.97	ns
S.D.	26.37	18.15	
Total Count			
Mean	444.14	235.92	9.23**
S.D.	168.51	60.50	df=126

MCDANIEL GROUP

	Manual	AFC	t-tests
Syllables			
Mean	357.34	139.27	17.07**
S.D.	89.34	31.39	df=110
Words			
Mean	108.09	104.30	ns
S.D.	40.98	32.19	
Sentences			
Mean	42.43	34.79	ns
S.D.	23.25	18.22	
Total Count			
Mean	506.96	278.35	11.77**
S.D.	127.65	66.75	df=110

** Indicates a significant difference between means at or below the .01 level.

TABLE 4

Comparison between Navy and McDaniel Groups for Speed (in seconds) of Manual Method (Passages I, III-X).

	NAVY GROUP	McDANIEL GROUP	t-tests
Syllables			
Mean	254.36	342.60	5.39**
S.D.	100.83	94.27	df=141
Words			
Mean	114.02	105.17	ns
S.D.	67.26	40.17	
Sentences			
Mean	46.40	40.86	ns
S.D.	26.22	22.78	
Total Count			
Mean	414.78	487.84	2.90**
S.D.	167.28	132.34	df=141

TABLE 5

Comparison between Navy and McDaniel Groups for Speed (in seconds) of Automated Methods (Passages II-X).

	NAVY GROUP (NAC)	McDANIEL GROUP (AFC)	t-tests
Syllables			
Mean	102.81	132.59	4.95**
S.D.	36.22	35.22	df=141
Words			
Mean	69.46	99.59	6.21**
S.D.	21.45	33.51	df=141
Sentences			
Mean	41.05	33.38	2.43*
S.D.	19.59	18.09	df=141
Total Count			
Mean	213.32	265.55	4.25**
S.D.	71.42	73.15	df=141

* Significant differences between means at or below the .05 level.

** Significant differences between means at or below the .01 level.

References

1. Biersner, R.J. Reading Grade Levels of Navy Rate Training Manuals, CNETS Report 2-75. The Chief of Naval Education and Training Support, Pensacola, Florida 32509, April 1975.

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3. Kincaid, J.P. and McDaniel, W.C. An Inexpensive Automated Way of Calculating Flesch Reading Ease Scores. Patent Disclosure Document #031350, U.S. Patent Office, Washington, D.C., 1974.

4. McDaniel, W.C. Inter-Analyst Reliability and Time Measures for the Automated and Manual Flesch Counts. M.A. Thesis, Georgia Southern College, Statesboro, Georgia 30458, July 1974.

5. Smith E.A., and Senter, R.V. Automated Readability Index. AMRL-TR-66-22. Wright Patterson AFB, Ohio: Aerospace Medical Division, 1967.

APPENDIX A

Description of the Automated Flesch Count (AFC)

AUTOMATED FLESCH COUNT[1]

The Automated Flesch Count apparatus consists of a Lafayette Instrument Company Model No. 15019 Electronic Metronome, a Lafayette Instrument Company Model No. 58004 Triple Date Recorder, and a master control box.

The metronome is controlled by a combination rate control and on-off switch. The metronome produces a constant rate of clicks that depends on the setting of the rate control. The rate of clicks may be varied from 40 beats a minute to approximately 208 beats per minute.

The master control box selects the proper element to be counted, i.e., syllables, words, or sentences. A hand-held switch is connected to the master control box to begin the count and end the count. A toggle switch in the lower right hand corner of the master control box is used to control the hand-held switch. The hand-held switch is a push-on/push-off type switch. Its operation is similar to a retractable ball point pen. In the lower left hand corner is a red pushbutton switch labeled SENTENCE COUNT. This switch will permit the operator to manually count elements. Each time the switch is depressed the selected display will advance by one.

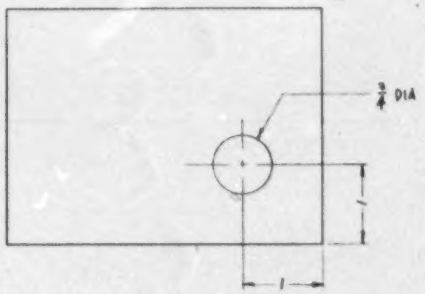
The triple display counter has three 4 digit displays. They are labeled as SYLLABLES, WORDS, AND SENTENCES. The selection of the display being used is determined by selection on the master control box. To the right of each display counter is a push button. Depression of this push button resets that display to zero. Each display is independently reset. An on-off switch located on the triple display counter provides power to the unit. A red indicator light glows when the equipment is turned on.

---

[1] This description provided by W. McDaniel in "Inter-Analyst Reliability and Time Measures for Automated and Manual Flesch Counts" (Reference 4).

APPENDIX B

Specifications for the Navy Automated Counter (NAC)



BOX DTLS - REAR
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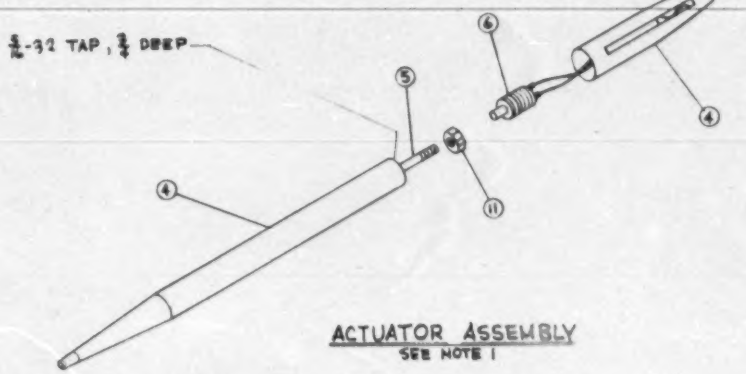
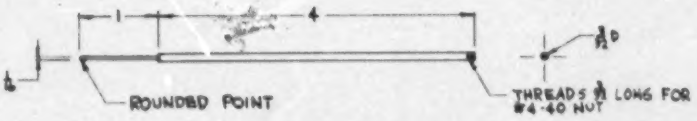


ACTUATOR ASSEMBLY
SEE NOTE 1



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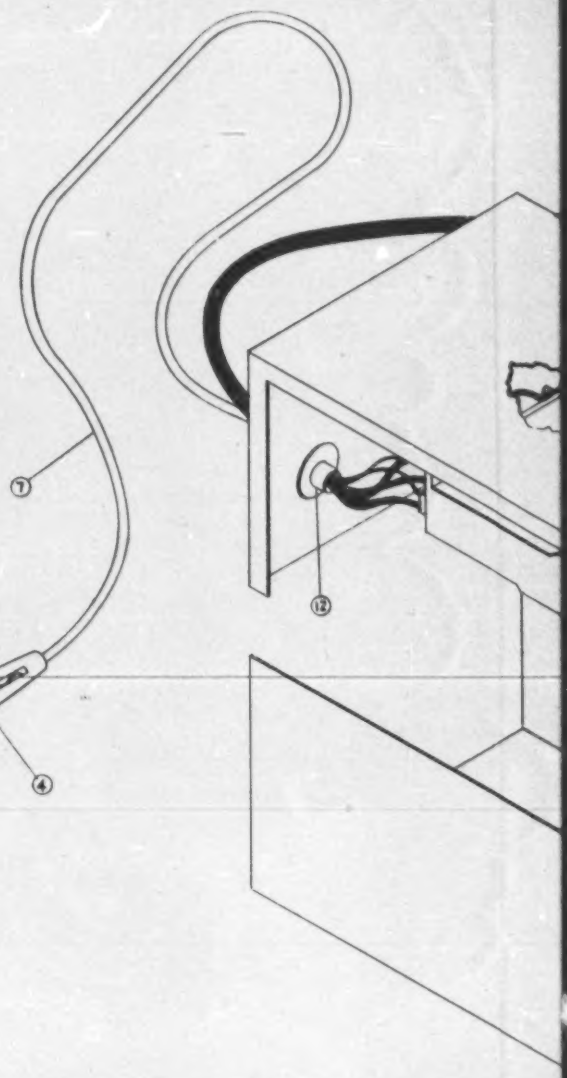

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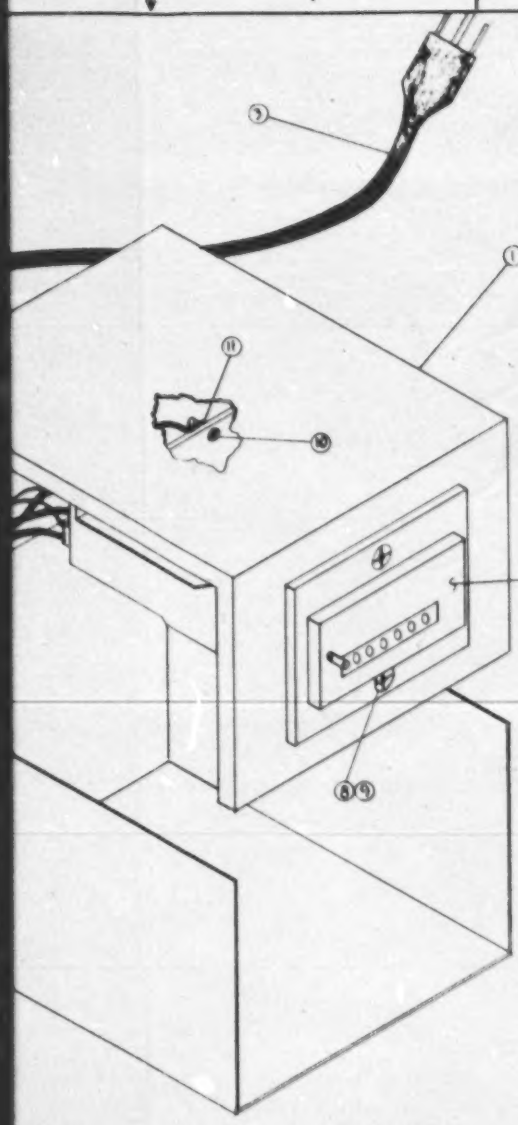

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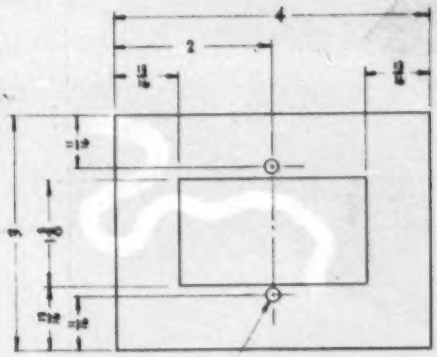

BOX DETAILS - FRONT
SCALE : FULL

NOTES:
1 REMOVE INSIDE PORTION OF FELT TIP PEN AND TAP THE END INDICATED TO ACCEPT THE THREADS ON THE SWITCH

ITEM	QTY	FSCM	PART NO.	SPEC-DWG NO	NOMENCLATURE
12	1 EA		2299	5925-263-6691	GROMMET, RUBBER - 1"
11	2 EA		MS35649-242		NUT, HEX #4-40
10	1 EA		MS35206-217		SCREW, #4-40 X 1/2 RD HD
9	2 EA		MS35649-282		NUT, HEX #8-32
8	2 EA		MS35190-255		SCREW, #8-32 X 1/2 C'SK PH
7	5 FT		15538-100		WIRE, 24 AWG, 2 COND, BELDEN
6	1 EA		99-101		SWITCH, GRAYHILL
5	1 EA	89297	ETE-4316-01-1		ROD, ACTUATOR (1/8 WELDING ROD, OR EQUIV)
4	1 EA				PEN, NYLON TIP MARKER, SCRIPTO
3	1 EA		6150-00-071-1180		CABLE ASSY
2	1 EA		5X642		COUNTER, ENM BRAND
1	1 EA	ILIB4	CU2105-A		BOX, MOUNTING

MATERIAL LIST

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ZONE	LTR	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES

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APPLICATION

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NAVAL TRAINING DEVICE CENTER
ORLANDO, FLORIDA

READABILITY COUNTER
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Readability	Reading Measurement
Reading Difficulty	Technical Reading
Reading Formulas	Writing Style

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

A statistical comparison was made between two automated devices which were used to count words, sentences and syllables (data points which are needed in the Flesch Reading Ease Score to determine the reading grade level of written material). The devices are the Automated Flesch Count (AFC) developed by Kincaid and McDaniel and the Navy Automated Counter (NAC) developed by the Navy to conduct a readability study of rate

training and correspondence manuals. Comparisons were made between the speed and reliability of the automated devices, and between the speed and reliability of each device and the manual method of counting data points.

Similar reliabilities were found for both of the devices and for the manual method. Counts made using the devices, however, were done almost twice as fast as counts done manually. The NAC was 20% faster than the AFC, but this difference may be largely attributed to a practice advantage which the subjects using the NAC had over the subjects using the AFC. Nevertheless, for any readability study which involves detailed counting of words, sentences, syllables, or similar data points, use of an automated device such as the NAC or AFC is highly recommended as being the most cost-effective technique available.